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R E P O R T

Maxus Realty Trust, Inc. v. RSUI Indemnity

Meteorological Analysis of Hurricane Katrina Wind and Storm Tide

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C O N F I D E N T I A L

KKAI Report #070917

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Part I. Hurricane Katrina Overview

Introduction

The first section of this report is a description of the essential factors of wind, central pressure, storm tide, and rainfall in association with Katrina's landfalls near Buras, Louisiana and near the mouth of the Pearl River at the Louisiana/Mississippi border. A more comprehensive summary can be found in Appendix A, which is the *Hurricane Katrina Tropical Cyclone Report* from the National Hurricane Center (NHC), Miami, Florida.

The "best track" of a tropical cyclone is the National Hurricane Center's official estimate of three characteristics of the cyclone: location of center, maximum one-minute surface wind speed, and minimum central sea-level pressure. The best track estimates are based on all available information including surface, aircraft reconnaissance, satellite, and radar data. Table 1 contains the best track for Katrina, with values listed every six hours during the period Katrina was classified as a tropical cyclone. Values are also listed for landfall times at the end of the table. Figure 1 shows Katrina's best track displayed graphically.

Discussion of Hurricane Katrina

Hurricane Katrina originated from the interaction of a tropical wave and the remnants of a tropical depression. The resulting weather system developed into a tropical depression on August 23, 2005, over the southeastern Bahamas. The depression gradually strengthened while moving northwestward over the Bahamas, reaching tropical storm status on 24 August and then category-one hurricane status (on the Saffir-Simpson scale) with maximum sustained winds of 80 mph late on 25 August. Turning west-southwestward, Katrina's center made landfall on the southeastern Florida coast shortly thereafter.

Katrina weakened to a tropical storm over south Florida, but quickly regained hurricane strength over the waters of the southeastern Gulf of Mexico on 26 August. During the next two days under highly favorable environmental conditions, Katrina strengthened from a minimal category-one hurricane to a category-five hurricane. It reached its peak intensity with maximum sustained

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(one-minute) surface wind speeds of 175 mph on the afternoon of 28 August while centered over the north-central Gulf of Mexico. During this same period, Katrina's wind field greatly expanded and by late on 28 August, tropical storm-force winds extended out about 225 miles from the center. The hurricane turned northward and began a rapid weakening phase during the 17 hours before landfall.

The center, or eye, of Katrina made landfall when it moved over the Mississippi River delta near Buras, Louisiana on the morning of 29 August as a category-three hurricane with 125 mph sustained winds. A few hours later, the center made a final landfall near the mouth of the Pearl River at the Louisiana/Mississippi border with winds estimated near 120 mph (also category-three) by the National Hurricane Center. The hurricane continued moving inland on a northward course at 18 mph, and weakened to a tropical storm late on 29 August over central Mississippi. By late on 30 August, Katrina had weakened to a depression over the Tennessee Valley and was later absorbed by a frontal system.

Wind Speed

Katrina was likely a category-four hurricane with maximum sustained winds of about 135 mph a couple of hours before the center made landfall near Buras, LA, but weakened to category-three at the time of landfall. The best track maximum one-minute wind speeds at the time of the landfalls at Buras and Pearl River were 125 mph and 120 mph, respectively. These are category-three hurricane wind speeds.

The highest sustained wind measured at the surface along the landfall area was 87 mph from a C-MAN station at Grand Isle, Louisiana. The instrument failed about two hours before the time of the center's closest approach to the station. The best-track landfall wind speeds are based on analyses of aircraft dropwindsondes released near the eyewall. The 120-mph official best-track estimate of the highest 1-minute sustained wind speed at landfall on the Mississippi coast refers to a small area of winds near the mouth of St. Louis Bay which borders Hancock and Harrison Counties. These best-track winds may have occurred only over water. The highest 1-minute sustained wind speeds along the coast decreased eastward and westward from the St. Louis Bay area. The highest estimated 1-minute sustained wind on the coast in Mississippi was 85 mph based on measurements of 10-minute average winds from an anemometer at the Ingalls Shipyard, located near Pascagoula in eastern Jackson County.

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Central Pressure

Central pressure, measured in the eye, is another gauge of a hurricane's intensity (generally, the lower the central pressure - the stronger the hurricane.) Although Saffir-Simpson categories are based on maximum sustained winds, hurricanes of a given category typically are associated with certain ranges of central pressure. For example, central pressures lower than 920 mb would usually be associated with a category-five hurricane. Katrina's central pressure dropped rapidly to 902 mb on the afternoon of 28 August, when the center of the hurricane was about 225 miles south of southeastern Louisiana, 17 hours from landfall. The central pressure rose to 920 mb at landfall near Buras, Louisiana. The central pressure continued to rise and was 928 mb at the Pearl River landfall. This value would normally be associated with a category-four hurricane but the maximum winds indicated that Katrina was a category-three hurricane at this point. According to the National Hurricane Center, the rapid weakening of Katrina prior to landfall was likely due to internal structural changes, specifically the deterioration of the inner eyewall without the complete formation of a new outer eyewall (Appendix A). The reason is that the maximum pressure gradient (the rate of change of pressure with distance from the eye), which is correlated with the wind speed, had begun to weaken and spread outward as Katrina approached land. This resulted in a decrease of the maximum wind speed, but caused an expansion of the area affected by hurricane force winds.

Katrina's 902 mb pressure on 28 August is the sixth lowest on record in the Atlantic basin, surpassed only by Wilma (882 mb in 2005), Gilbert (888 mb in 1988), the Labor Day Hurricane of 1935 (892 mb), Rita (897 mb in 2005), and Allen (899 mb in 1980).

Even though the hurricane had weakened from category-five to three at landfall near Buras, Louisiana, the central pressure of 920 mb is still the third lowest on record for a U.S. landfall, behind Camille (909 mb in 1969) and the Labor Day Hurricane (892 mb in 1935).

Storm Tide

Katrina's storm surge and the astronomical tide combined to generate maximum observed storm tide heights of 20-28 feet above the North American Vertical Datum of 1988 (NAVD88) along the Mississippi coast. NAVD88 is a vertical datum established so that the heights of land, structures, and water surfaces all have a common reference. Along the Mississippi coastal area, the baseline or zero value for NAVD88 is approximately 0.5 feet below mean sea level. The maximum storm tide heights of 20 feet or greater covered a 55-mile wide swath that extended

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eastward from western Hancock County through all of Harrison County to near the town of Gautier in central Jackson County. The storm tide heights decreased eastward from Gautier, but 10-15 foot heights were still measured as far as the Alabama coast, 15 miles further east. The storm tide penetrated up to six miles overland and 12 miles up bays and rivers over portions of coastal Mississippi.

The massive storm tide along the Mississippi coast is the result of the storm's extensive reach of hurricane force winds as well as three other important factors. First, the Mississippi coastline forms an approximate right angle with the Mississippi River delta creating a "corner" for trapping water. Second, the very shallow waters of the Mississippi Sound pile up water to higher elevations with the same winds when compared to locations where the water is deeper near the shoreline. Third, Katrina tracked due north during its two Gulf coast landfalls allowing the extensive hurricane wind field north and east of the center to push water directly onto the shallow Mississippi Sound and into the "corner". Even though Hurricane Camille of 1969 was a more intense category-five at landfall, Katrina produced higher storm tide heights over a much wider area.

Rainfall

Rainfall totals were up to 12 inches over parts of southeastern Louisiana and up to 10 inches over southwestern Mississippi. These amounts are somewhat greater than would normally be expected with a hurricane moving at a speed of 18 mph, since the faster a hurricane moves, the less time there is for rainfall to accumulate in a given location.

Overview Conclusions

Hurricane Katrina had sustained surface winds of up to 120 mph when it made landfall along the Louisiana/Mississippi coast and was a category-three event on the Saffir-Simpson hurricane scale. Maximum storm tide heights reached from 20 to 28 feet above NAVD88 along the Mississippi coast. These values are unusually high for a category-three hurricane and were caused by the factors discussed previously.

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Part II. Wind and Storm Tide at the Waverly Apartment Complex Site

Introduction

The second part of this report provides estimates of the highest wind and highest storm tide flooding that occurred at the Waverly Apartment Complex, 100 Waverly Drive, Bay St. Louis, MS, along with the observations and model guidance used to make the estimates. The Waverly Apartment Complex is composed of 16 two story apartment buildings and a one story clubhouse. The site is located about 2.3 miles from the Gulf of Mexico and 1.5 miles from the Jourdan River (Figure 13). There are many trees and structures between the Waverly Apartment Complex and the Gulf of Mexico and between the Complex and the Jourdan River. Based on the U.S. Geological Survey 10-meter National Elevation Data (NED), the ground was determined to be 7 feet above NAVD88. This elevation is confirmed by engineering reports that list ground elevations around the apartments ranging from 6.7 to 7.4 feet. The engineering reports also indicated that the heights of the finished first floors were approximately 10.8 feet and the finished second floors ranged from 20.0 to 20.5 feet.¹

Wind Speed and Direction

The center of Katrina made landfall early on August 29, 2005, near Buras, Louisiana, and made another landfall near the mouth of the Pearl River at the Louisiana/Mississippi border a few hours later. The strongest winds occurred near Buras and then along the Mississippi coast near the entrance to St. Louis Bay which borders eastern Hancock and western Harrison Counties.

When estimating wind speed values at a particular location, nearby National Oceanographic and Atmospheric Administration (NOAA) weather observations are given the most weight, when they are available. Other factors used to make estimates are: unofficial observations, NHC best-track data, and numerical weather analysis models. The NHC definition of a hurricane's

¹ We reserve the right to change these figures if additional data become available.

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maximum sustained wind speed refers to the highest value of the wind averaged over a one-minute period, at a height of 33 feet above unobstructed terrain or water surface.

The two observing stations nearest the Waverly Apartment Complex failed before the maximum winds arrived: Keesler Air Force Base and Gulfport-Biloxi airport. Their highest observed wind speeds are listed in Table 2, along with wind data recorded at other locations. Wind data from the coastal areas of Louisiana, Mississippi and Alabama are plotted in Figure 2. The data for the Ingalls Shipyard in Pascagoula provides a nearly complete record of sustained winds at the coast during the passage of the hurricane (Figure 3). A spreadsheet of the Ingalls data is shown in Appendix B. The shipyard is located about 50 miles east of the Waverly Apartment Complex.

The Ingalls wind data consists of 10-minute average wind speeds. The usual practice is to define a sustained surface wind as a 1-minute average of wind speeds measured at 33 ft. above the surface. An estimate of the magnitude of a 1-minute average wind speed may be obtained by taking 112 percent of the corresponding 10-minute average. Applying this conversion to the Ingalls maximum 10-minute wind speed of 78 mph gives an estimated 1-minute average speed of 87 mph. The Ingalls anemometer was located at an elevation of 62 feet, mounted on a tower attached to the southeast corner of a 50 foot high building. Since the wind was influenced by local effects, including the building, it is not considered to be representative of an unobstructed location but can be used along with other data to obtain an approximate assessment of the evolution of the wind field associated with the hurricane. Finally, a slight reduction of the 87 mph estimated wind speed at 62 feet to 85 mph can be made as a rough adjustment to the standard 33 ft. measurement height. The highest wind speed at Ingalls was observed about 0920 CDT (Figure 3).

A complete record of wind speed and direction from a site about 8 miles inland during the passage of the hurricane was obtained from three instrumented towers located at Stennis International Airport, located about 6.5 miles northwest of the Waverly Apartment Complex. These instruments were operated by Texas Tech University, and the results are described in the report: *Hurricane Katrina Deployment Summary*, Texas Tech University Hurricane Research Team, Wind Science and Engineering Research Center, Lubbock, Texas, 16 November 2006 (Appendix D). Wind speed data from one of the three Texas Tech instrumented towers (the PMT White Tower) is shown in Figure 4. The data consist of 1-minute average wind speeds and directions. The time history of the wind records sheds some light on the timing of the arrival of the highest winds at the Waverly Apartment Complex. Since the Waverly Apartment Complex is much closer to the Stennis Airport than it is to the Ingalls Shipyard, the evolution of the winds at the Stennis site is more representative of what occurred at the Waverly Apartment Complex.

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However, since the Ingalls Shipyard is on the coast, its wind record illustrates the sudden increase in wind speed as the wind direction shifts from offshore to onshore. The maximum wind of 68 mph occurred at the Stennis site at about 0948 CDT (Figure 4). This compares with the arrival time of the maximum winds of 85 mph at the Ingalls site at 0920 CDT. Figure 4 also indicates that the eastern side of Katrina's eye moved over the Stennis site. This is noted by the decrease in winds to 27 mph at 1008 CDT. The winds then increased again as the hurricane's southeastern eyewall moved over the site and then decreased as the hurricane moved away. The reasons that the highest sustained wind measured at the Stennis site was only 68 mph (i.e. below hurricane strength) are that the anemometer location was about 8 miles inland from the Mississippi Sound, the site was obstructed by trees in the vicinity and that the hurricane was weakening as it moved inland. This is explained more fully in Appendix D.

Additional guidance concerning wind speed and direction estimates at the Waverly Apartment Complex is shown in Figures 5-9, which illustrate NOAA Hurricane Research Division (HRD) Hurricane Wind (HWind) analyses of the 1-minute 33-foot wind speeds of Katrina at 29/0100 CDT, 29/0400 CDT, 29/0700 CDT, 29/1000 CDT, and 29/1300 CDT respectively. These wind speed analyses are based on a multitude of data sources, including surface observations, aircraft, satellite, etc. The HWind analysis provides both over-water and over-land wind speed estimates. Over-water HWind wind speed estimates are higher than over-land wind speed estimates.

Because the Waverly Apartment Complex is located approximately 3.25 miles inland from the Gulf of Mexico, the winds there would be considered over-land wind speeds. The HWind over-land wind speed estimates at the Waverly Apartment Complex are plotted in Figure 10. The time record of wind speed and direction from Stennis is added to illustrate the evolution and fluctuation of winds during the period. The highest HWind wind speed estimate is 99 mph at 1000 CDT. Recalling that both the Ingalls and Stennis highest wind speeds occurred between 0900 and 1000 CDT, ***our estimate of the maximum sustained wind speed at the Waverly Apartment Complex is approximately 100 mph***, likewise occurring between 0900 and 1000 CDT on 29 August. After a brief lull in the eastern edge of the eye, the winds rapidly shifted to the southeast and briefly increased to about 95 mph as the trailing edge of the eyewall passed over the site around 1030 CDT. Winds then began to subside rapidly as the hurricane moved northward away from the site. However, the brief lull in the winds as the eastern edge of the eye passed over the Stennis (Figure 4) and Waverly Apartment Complex is not reflected in the HWind data, since it is a composite over a few hours.

In the absence of recorded meteorological observations at the site, HRD analyses, along with the rate of increase of winds at the Stennis and Ingalls locations yield the best available estimate

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concerning wind speeds and directions at the Waverly Apartment Complex. The time plot of wind speed at Ingalls (Figure 3) shows a rapid increase from about 40 mph to 68 mph beginning around 0600 CDT. At the same time the wind direction shifts from easterly to southeasterly, that is, from an over-land to an over-water trajectory. The change in the rate of increase of wind at the Stennis site, 6.5 miles northwest of the Waverly Apartment Complex, commenced about an hour earlier even though the wind direction remained over land, from the east-northeast (Figure 4). This is because the site was beginning to feel the effects of the strong winds in the right front quadrant of the hurricane as it began to move northward toward the coast near the LA-MS border. A similar change in the rate of increase of the winds from the HWind analysis is noted at the Waverly Apartment Complex (Figure 10). Based on these data, 40 mph wind speeds likely reached the Waverly Apartment Complex around 0100 CDT on 29 August and 75 mph hurricane force wind speeds likely reached the site around 0600 CDT. Sustained wind directions at the site can be estimated from the wind analyses in Figures 5-9 and the time history of wind direction at the Stennis Airport (Figure 4). The wind direction at the Waverly Apartment Complex remained out of the northeast quadrant during the night and early morning hours of 29 August as the eye of Katrina approached. ***As the eastern part of the eye passed over the site, the wind veered or turned clockwise and came out of the east around 1000 CDT, out of the southeast around 1030 CDT, out of the south around 1100 CDT and then remained out of the southwest for the rest of the day.***

Wind gusts are not given as part of the National Hurricane Center post-storm best track, even though gusts are given in operational advisories. This is because gusts are generally not measured by any of the methods of determining wind speed except *in situ* observations using an anemometer. Additionally, wind gusts are highly variable in space and time, and therefore an estimate of a wind gust speed at a particular location without a nearby observation would be subject to large errors. For those reasons, wind gust values are not considered sufficiently reliable to be included in the NHC best track. Consistent with this approach, no attempt has been made here to estimate wind gust speeds at the Waverly Apartment Complex.

The National Climatic Data Center (NCDC) of NOAA compiles data on all significant hazardous weather and flood events in the United States. These data are listed in the monthly NCDC publication, *Storm Data*. According to *Storm Data*, there were 13 tornadoes recorded in Mississippi on 29 August 2005. No tornadoes were recorded near the Waverly Apartment Complex. Moreover, none of the 13 tornadoes that did occur were in the coastal counties of Hancock, Harrison, or Jackson.

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Figure 14 shows a post Katrina aerial photo of the Waverly Apartment Complex and surrounding area. Damage to the roof of each apartment building is visible. Of interest is the tendency for much of the damage to be located on the southeast facing side of the apartments.

Storm Tide Flood Levels

Storm surge height at a particular coastal location is defined as the height of water above predicted astronomical tide at that location. Storm tide is defined as the combination of the astronomical tide and the storm surge. The storm tide is often referenced to one of two vertical data reference levels, NGVD or NAVD88. The difference between NGVD and NAVD88 in this area is only a few inches. In this report, all water heights are referenced to NAVD88.

The most accurate method to measure storm tide heights is with a recording tide gage. In the absence of gage data, post-storm surveying of water marks on structures is used to estimate storm tide values. Water marks are classified as either inside still-water marks, in which observations are taken from inside structures that were flooded in the event, or outside high-water marks, in which observations are taken from debris lines and other external structural evidence. Gage recordings and inside still-water marks are representative of the storm tide because they do not have additional elevation due to waves. Outside high-water marks include wave heights superimposed on storm tide heights.

There was widespread failure of tide gages along the coast. However, many high-water marks were collected along coastal Mississippi by the Federal Emergency Management Agency (FEMA). These high-water marks are documented in the report *Final Coastal and Riverine High Water Mark Collection for Hurricane Katrina in Mississippi* (FEMA-1604-DR-MS, Task Orders 413 and 420 March 14, 2006). Figure 11 is taken from this FEMA report and shows the observed high-water marks in the vicinity of the Waverly Apartment Complex. All of the marks are referenced to NAVD88. The closest high water mark, located just to the northeast of the Waverly Apartment Complex is 26.9 feet. Two additional marks are located just to the southeast and are 24.5 and 23.0 feet.

In addition, the engineering reports indicated that the apartments had high water marks approximately 3 feet above the second floors or approximately 23 to 23.5 feet above NAVD88. Inspection of damage photos of the second floor in each building show high water marks that are very close to 3.5 feet above the second floor in some buildings but approximately 3 feet in others. Since the second floor elevations vary from 20 to 20.5 feet between the buildings it is likely that the 3.5 foot marks are occurring in buildings with a second floor elevation of 20 feet

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while the 3 foot elevations are occurring in buildings of 20.45 feet. This indicates a high water elevation of 23.5 feet for the Waverly Apartment Complex. This value falls within the range of the three nearby high water marks mentioned above.

The National Weather Service Sea, Lake, and Overland Surges from Hurricanes (SLOSH) storm surge model was run using the Katrina best track data. The model run was initiated with a water elevation of 2.5 feet to take into account that the hurricane arrived near the time of high astronomical tide. In addition, a correction for the 2005 height of mean sea level along the Mississippi coast and a small correction for pre-Katrina water elevations occurring along the coast were also incorporated into the 2.5-foot value. Thus, the water elevations produced by the SLOSH simulation reflect storm tide and can be compared directly to the observed storm tide elevations. A time-history of the SLOSH model Katrina run for a location near the Waverly Apartment Complex is shown in Figure 12. A spreadsheet table of the SLOSH data output used in Figure 12 is located in Appendix C. The SLOSH model run at the Waverly Apartment Complex shows a maximum storm tide of 22.5 feet at 1030 CDT.

Based on an analysis of the three nearby measured high water marks and the Waverly Apartment Complex value, ***we estimate that the actual storm tide level at the Waverly Apartment Complex reached approximately 23.5 feet above NAVD88.*** When the storm tide reached its maximum, the water depth above the ground at the Waverly Apartment Complex was approximately 16.5 feet. This water depth would support large superimposed waves, but the trees surrounding the site limit the ability of the wind to generate them. Thus, waves were likely on the order 3 feet or less. The SLOSH model hydrograph was then increased approximately 5 percent to make it agree with the estimated maximum value of 23.5 feet. The adjusted SLOSH hydrograph is also shown in Figure 12.

As stated in the Introduction, the first floor of each apartment was approximately 10.8 feet above NAVD88. Based on the adjusted SLOSH model results, the storm tide reached 10.8 feet above NAVD88 near 0840 CDT and this is when water is estimated to have first entered the Waverly Apartments. At this time the winds were blowing approximately 95 mph from the east-northeast. The adjusted SLOSH model hydrograph shows storm tide values rising rapidly an additional 8 feet in 50 minutes causing total inundation of the first floor level of the apartments. At about this time, 0930 CDT, the wind reached its maximum of 100 mph from the east. During the next hour the storm tide continued to rise rapidly to its maximum of 23.5 feet at 1030 CDT. In this same time period the wind speed decreased as the eastern side of the eye passed over the Waverly Apartment Complex and then increased again as the southeastern eyewall approached. At 1030

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CDT the winds were estimated to be 95 mph from the southeast. After this time the winds began to decrease and continued to shift to the southwest. ***The storm tide remained above the height of the first floor ceiling for approximately 3.5 hours. At about 1300 CDT the storm tide level dropped below the ceiling of the first floor level. At this time the winds were approximately 60 mph.***

Conclusions

Our estimate of conditions at the Waverly Apartment Complex during Hurricane Katrina indicate that the highest sustained winds were approximately 100 mph and that the storm tide was approximately 23.5 feet above NAVD88 with waves superimposed. Based on the SLOSH model results and wind data and estimates described above, at the time that the storm tide first reached the Waverly Apartment Complex and entered the first floor of the apartments, near 0840 CDT, sustained wind speeds were near 95 mph. Over the next 50 minutes the storm tide water levels continued to climb at the Waverly Apartment Complex covering the first floor level at 0930 CDT. At this same time wind speed reached its maximum of 100 mph. One hour later, the maximum storm tide occurred at 1030 CDT and the winds were blowing at about 95 mph from the southeast. This placed approximately 3 to 3.5 feet of water above the second floor of the apartments. Both wind and storm tide levels began to decrease after this time. The first floor level of each apartment remained under water for approximately 3.5 hours. Also, waves, 3 feet or less, impacted the structures.

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Table 1. National Hurricane Center best track of Hurricane Katrina, August 2005.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
23 / 1800	23.1	75.1	1008	30	Trop. dep.
24 / 0000	23.4	75.7	1007	30	"
24 / 0600	23.8	76.2	1007	30	"
24 / 1200	24.5	76.5	1006	35	tropical storm
24 / 1800	25.4	76.9	1003	40	"
25 / 0000	26.0	77.7	1000	45	"
25 / 0600	26.1	78.4	997	50	"
25 / 1200	26.2	79.0	994	55	"
25 / 1800	26.2	79.6	988	60	"
26 / 0000	25.9	80.3	983	70	hurricane
26 / 0600	25.4	81.3	987	65	"
26 / 1200	25.1	82.0	979	75	"
26 / 1800	24.9	82.6	968	85	"
27 / 0000	24.6	83.3	959	90	"
27 / 0600	24.4	84.0	950	95	"
27 / 1200	24.4	84.7	942	100	"
27 / 1800	24.5	85.3	948	100	"
28 / 0000	24.8	85.9	941	100	"
28 / 0600	25.2	86.7	930	125	"
28 / 1200	25.7	87.7	909	145	"
28 / 1800	26.3	88.6	902	150	"
29 / 0000	27.2	89.2	905	140	"
29 / 0600	28.2	89.6	913	125	"
29 / 1200	29.5	89.6	923	110	"
29 / 1800	31.1	89.6	948	80	"
30 / 0000	32.6	89.1	961	50	tropical storm
30 / 0600	34.1	88.6	978	40	"
30 / 1200	35.6	88.0	985	30	trop. dep.
30 / 1800	37.0	87.0	990	30	"
31 / 0000	38.6	85.3	994	30	extratropical
31 / 0600	40.1	82.9	996	25	"

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31 / 1200					merged with front
28 / 1800	26.3	88.6	902	150	Max. wind and min. pressure
25 / 2230	26.0	80.1	984	70	FL landfall at Broward/Miami-Dade County line
29 / 1110	29.3	89.6	920	110	Landfall near Buras, LA
29 / 1445	30.2	89.6	928	105	Landfall near LA/MS border

Table 2. Katrina Maximum observed wind speeds.

Maximum sustained wind speed(mph)	Maximum gust (mph)	Date/time (August CDT) of maximum sustained wind	Location
78	117	29/0920	Ingalls Shipyard, Pascagoula
68	105	29/0948	Stennis International Airport (approx. 8.5 miles inland)
67	76	29/0813	Cherokee Elementary, Pascagoula
67	84	29/0901	Mobile
60	98	29/0900	Keesler AFB Instrument failed
46	63	29/0525	Gulfport-Biloxi airport Instrument failed

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Appendix C. Spreadsheet of SLOSH model output (separate file)
Appendix D. *Hurricane Katrina Deployment Summary, Texas Tech University Hurricane Research Team, Wind Science and Engineering Research Center, Lubbock, Texas, 16 November 2006 (separate file)*

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KKAI Report: 070917
Prepared for Clausen Miller P.C.
Report date September 14, 2007

Respectfully submitted,

s/ **Brian R. Jarvinen**

Brian R. Jarvinen

Respectfully submitted,

s/ **Miles B Lawrence**

Miles B Lawrence

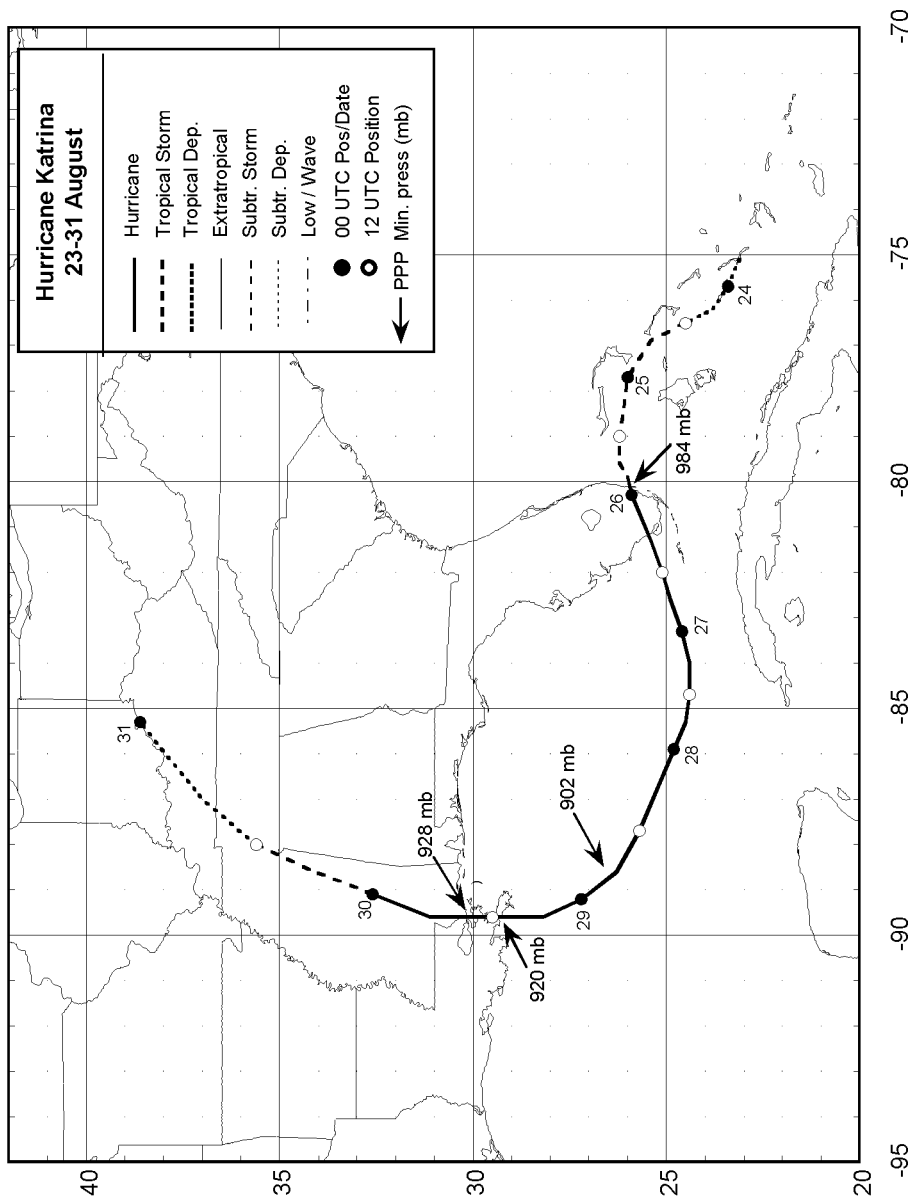
Respectfully submitted,

s/ **Joseph M. Pelissier**

Joseph M. Pelissier

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**Figure 1. Map of Hurricane Katrina best track
(courtesy of National Hurricane Center).**

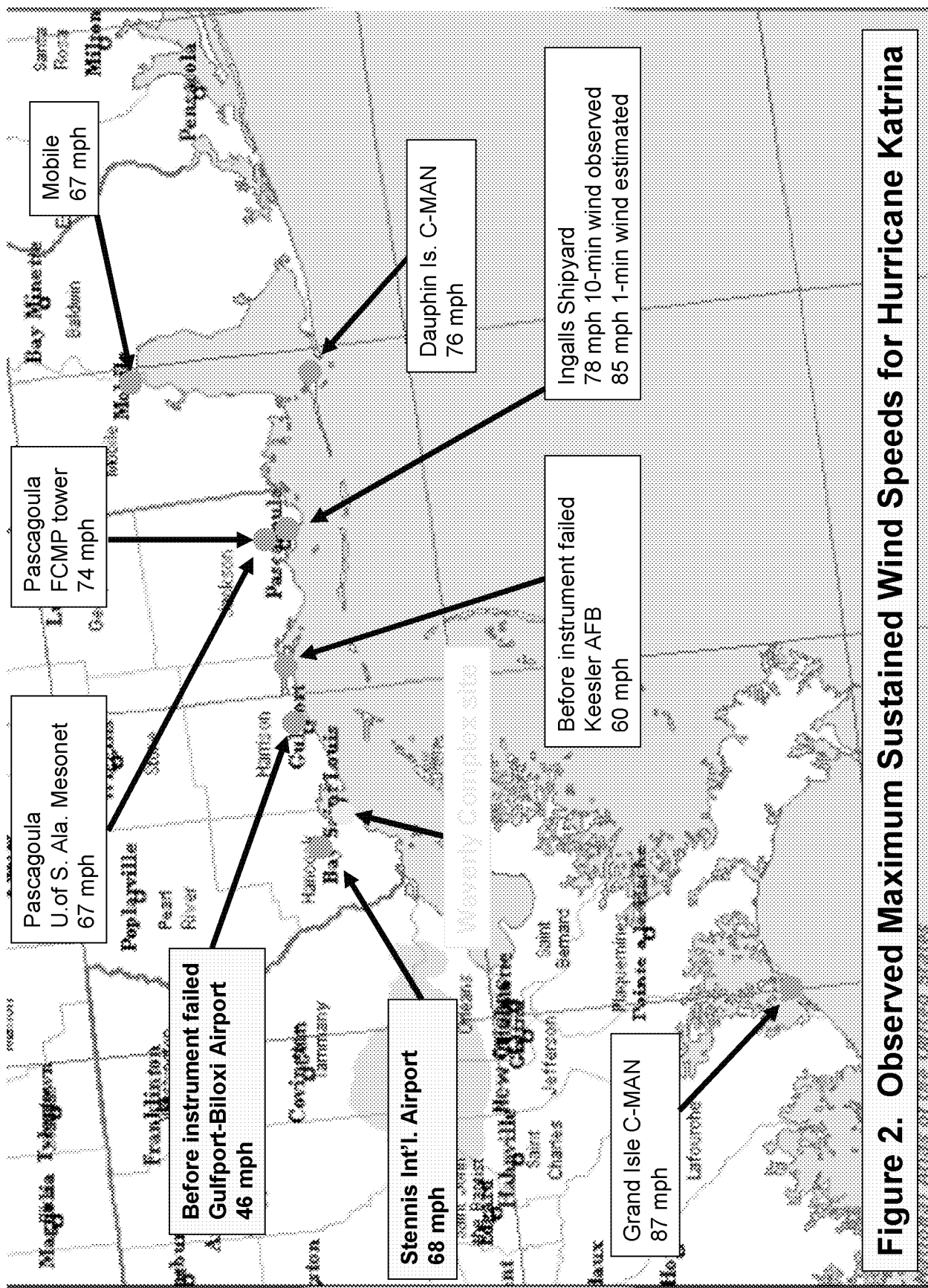


Figure 2. Observed Maximum Sustained Wind Speeds for Hurricane Katrina

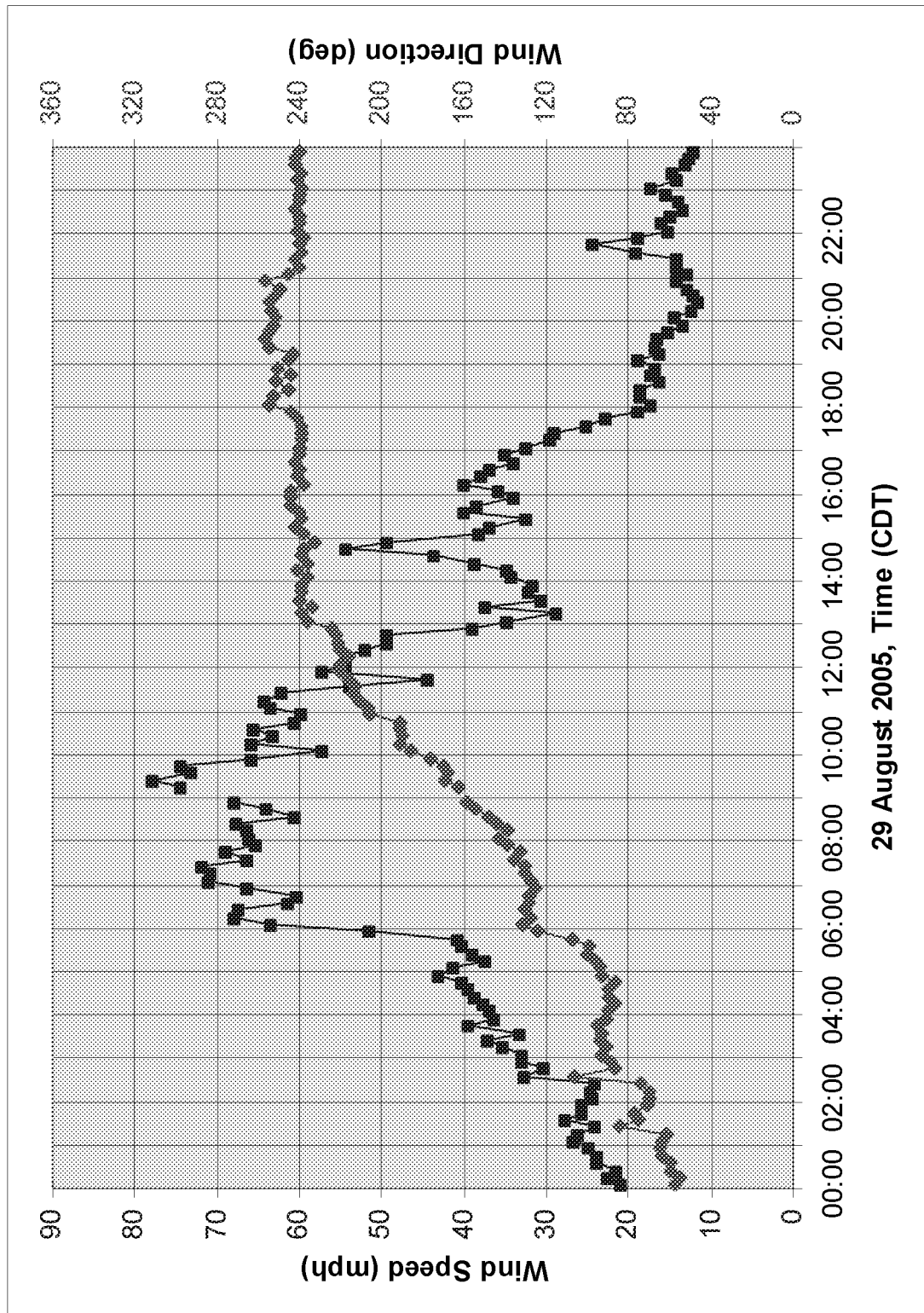


Figure 3. Observed 10-minute sustained wind speed (blue) and direction (red) at the Ingalls Shipyard during the passage of Hurricane Katrina, 29 August 2005.

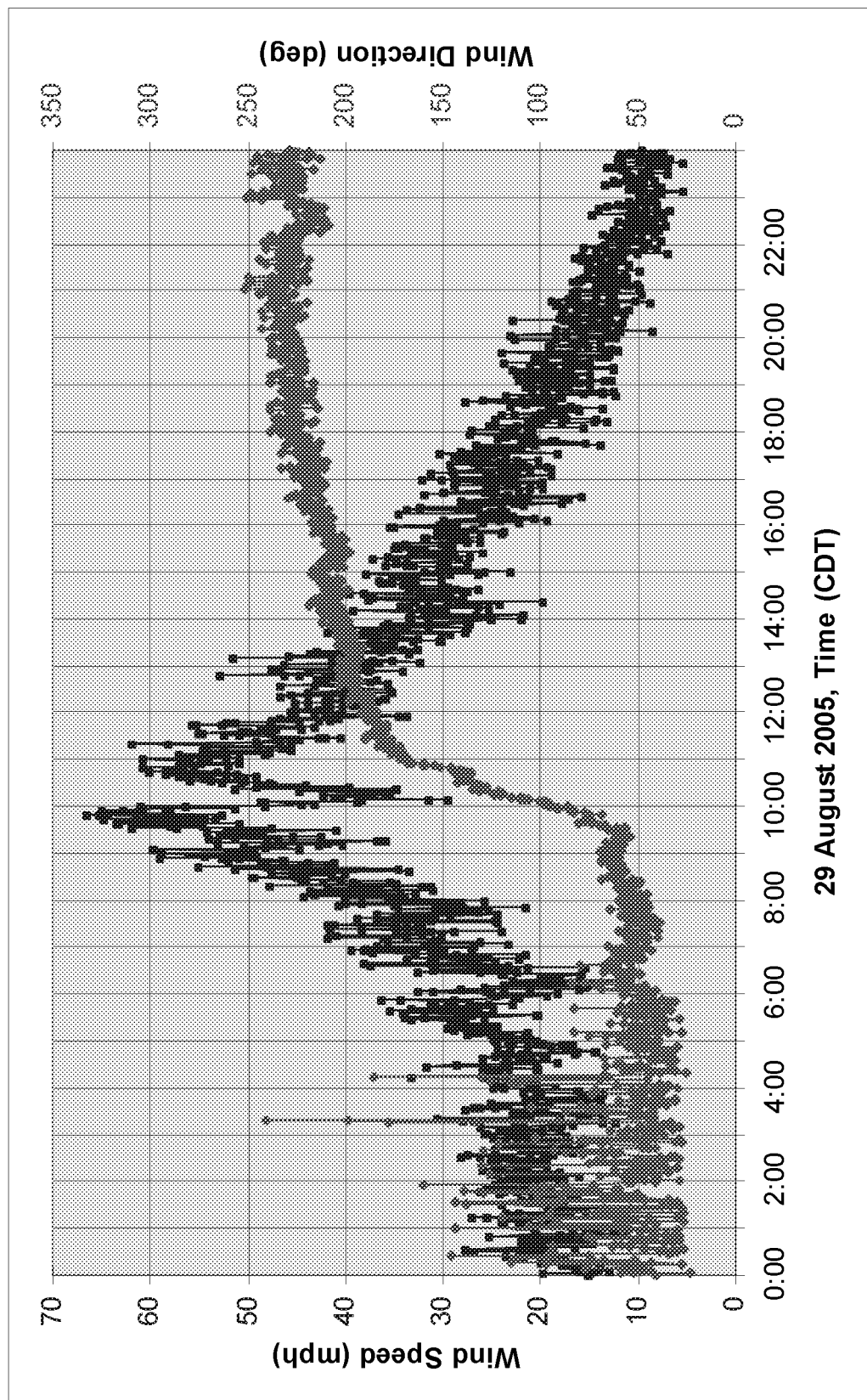
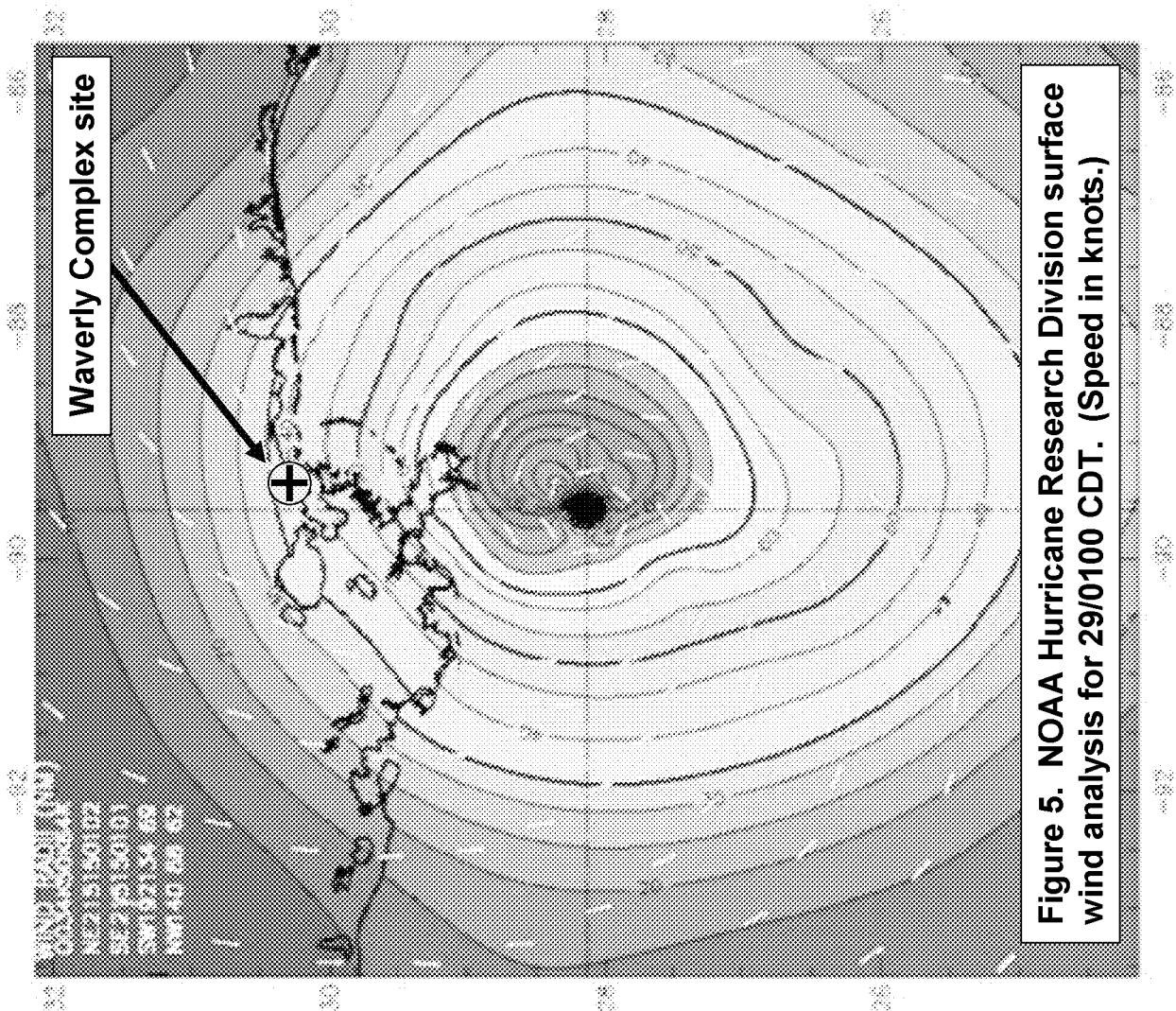


Figure 4. Observed 1-minute sustained wind speed (blue) and wind direction (red) at the Stennis site during the passage of Hurricane Katrina, 29 August 2005

Data Courtesy of Texas Tech



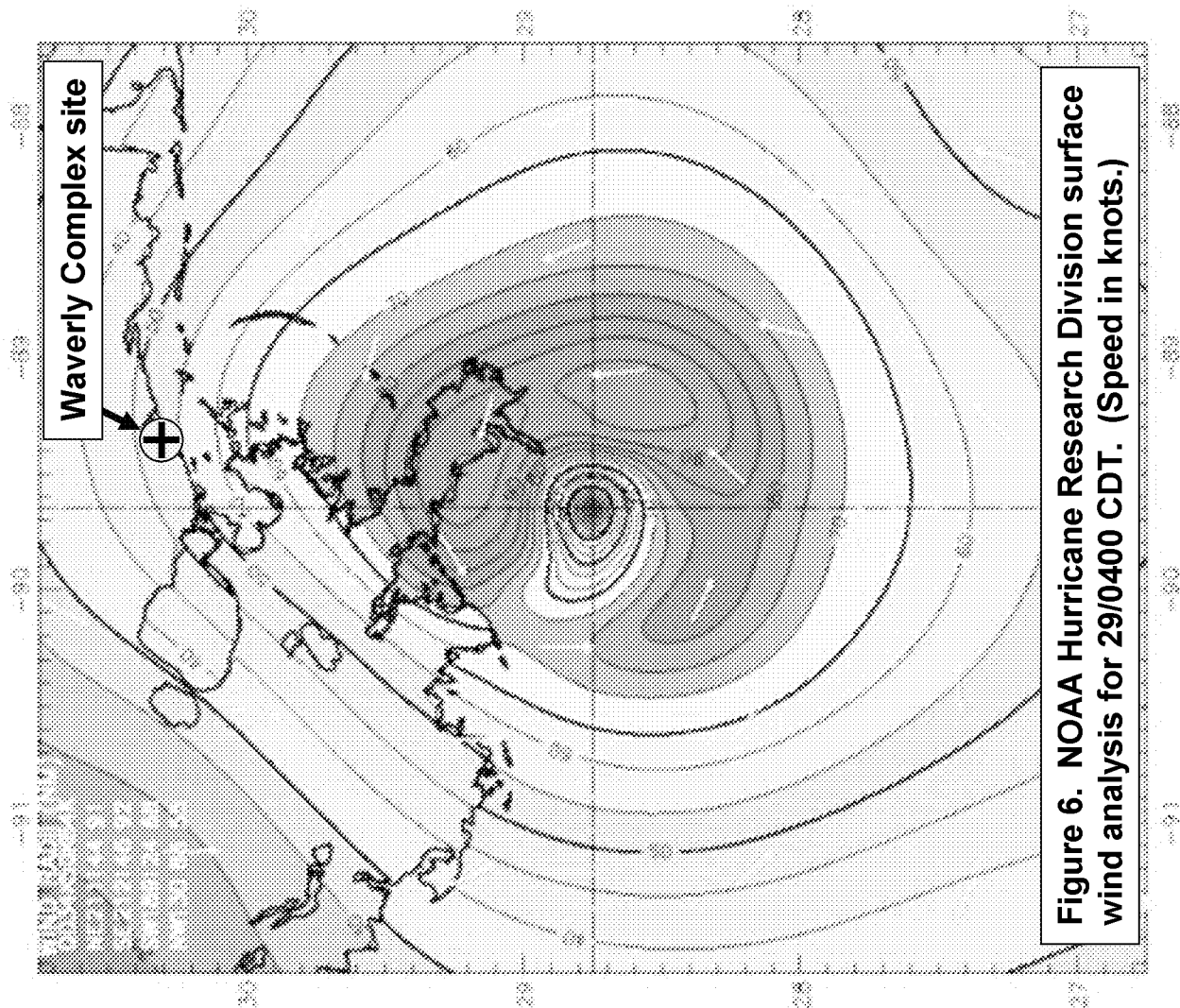


Figure 6. NOAA Hurricane Research Division surface wind analysis for 29/0400 CDT. (Speed in knots.)

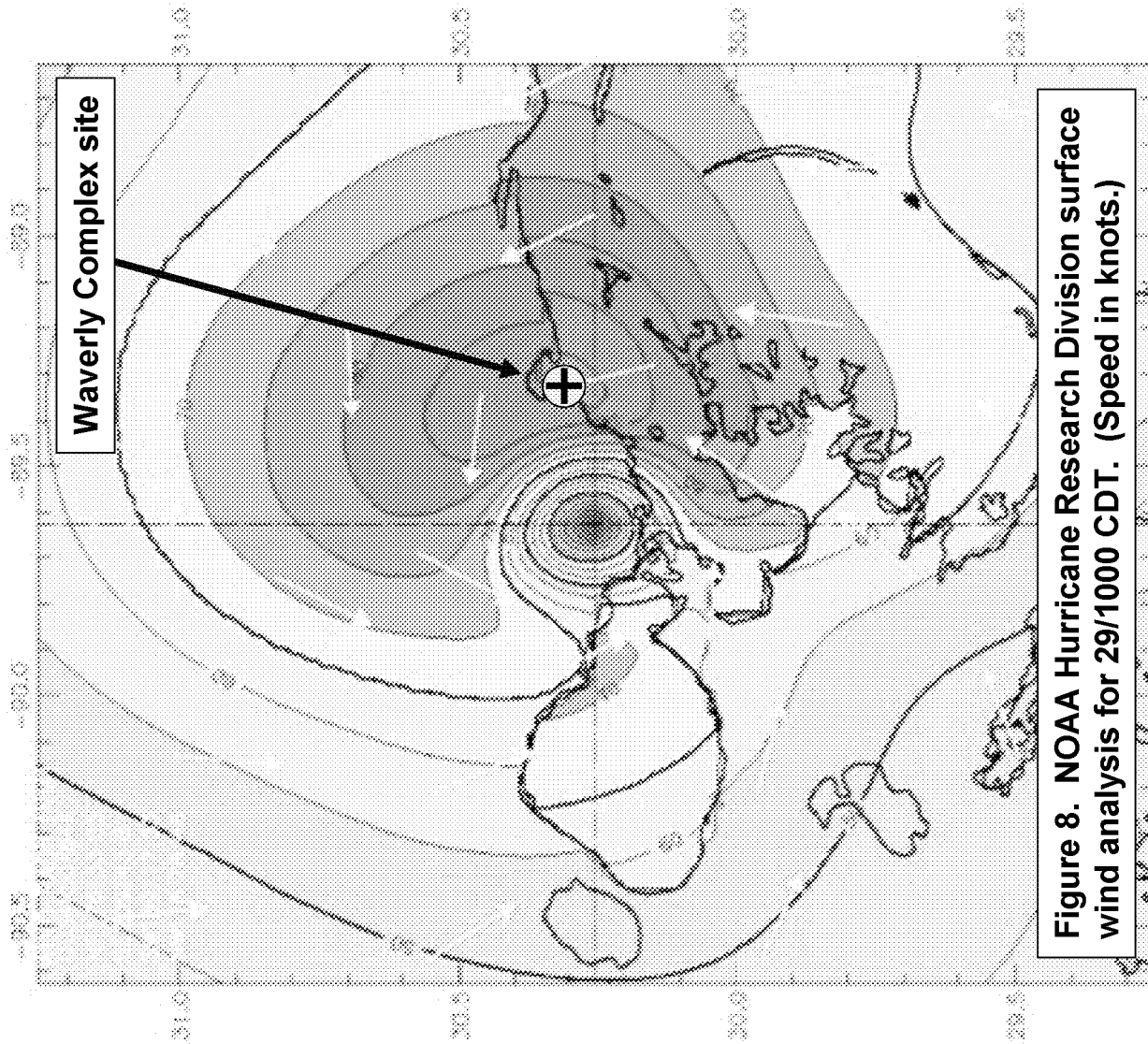


Figure 8. NOAA Hurricane Research Division surface wind analysis for 29/1000 CDT. (Speed in knots.)

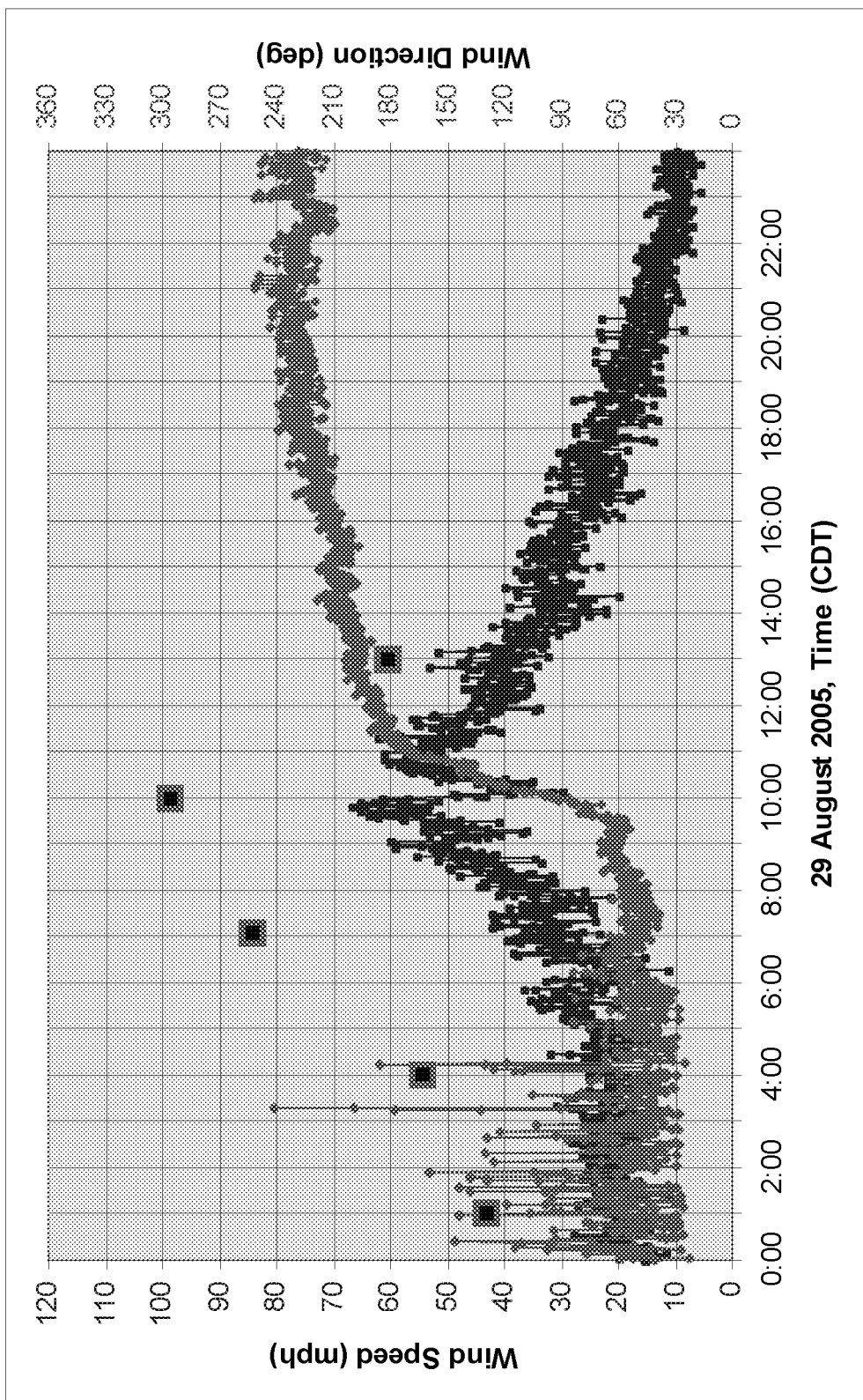
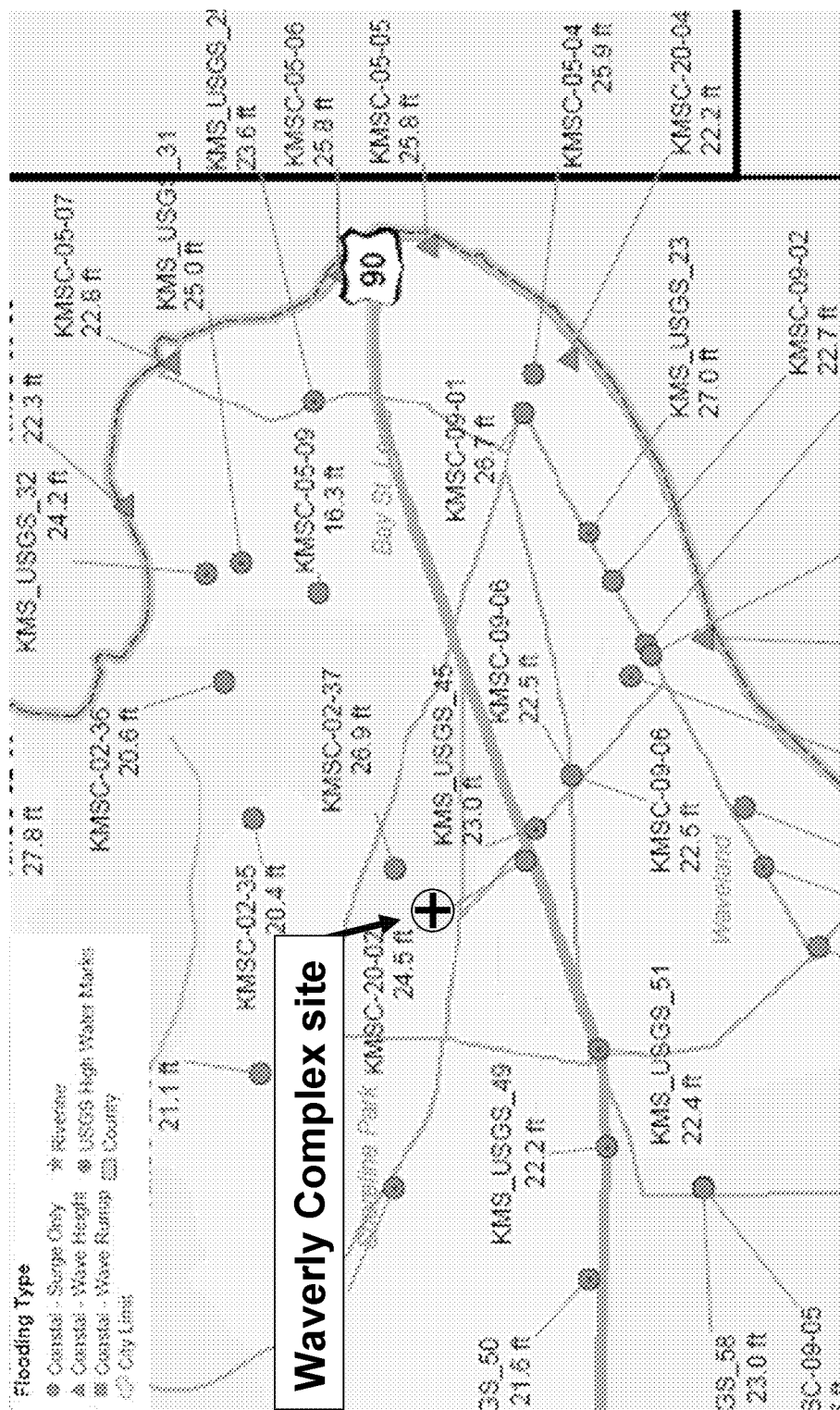


Figure 10. HRD HWind sustained over-land (■) wind speed estimates for the Waverly Complex site. Stennis International Airport sustained wind speed (blue) and wind direction (red) observations.



SLOSH Storm Tide at Waverly Complex Site

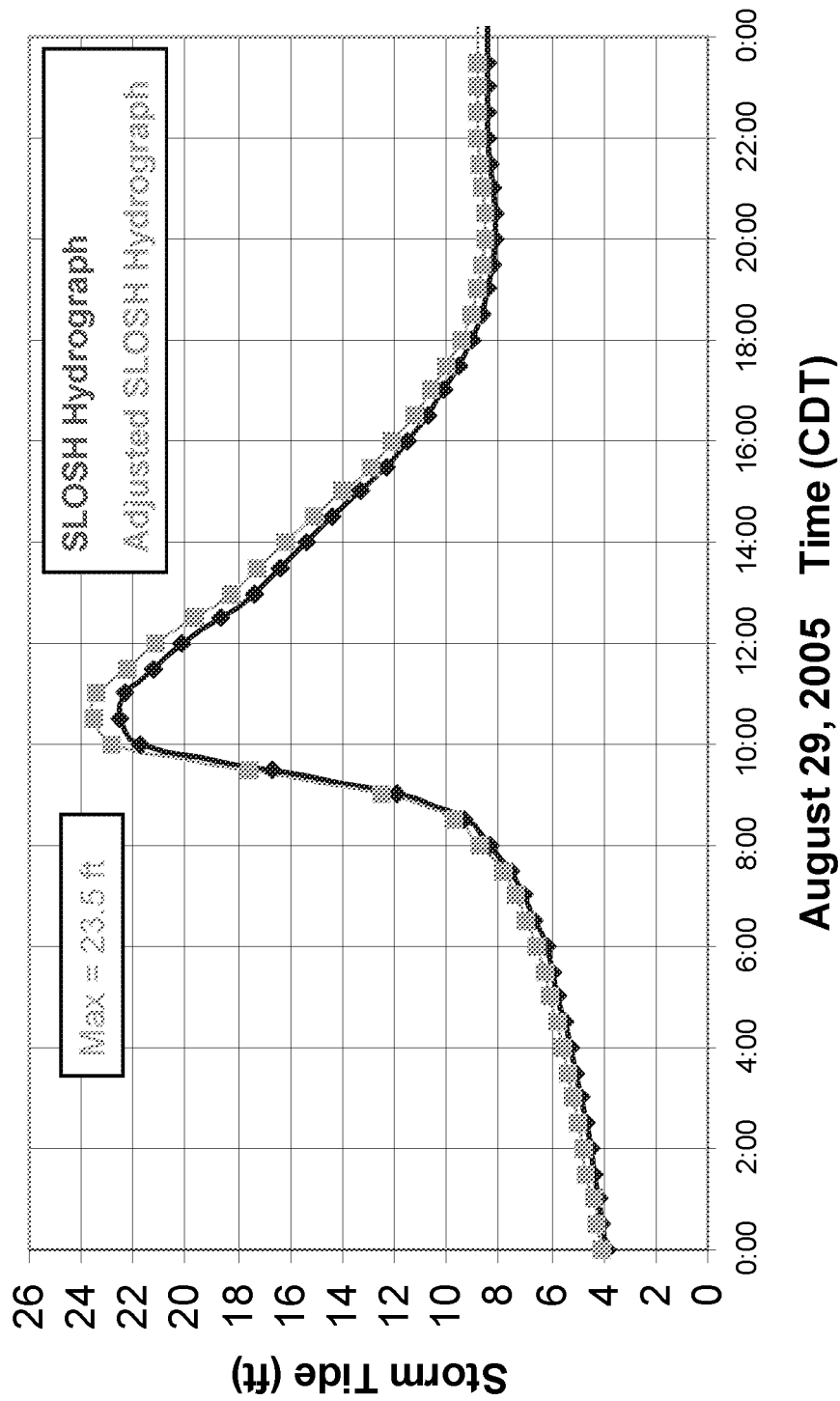


Figure 12. SLOSH and Adjusted SLOSH storm tide model output for the Waverly Complex site

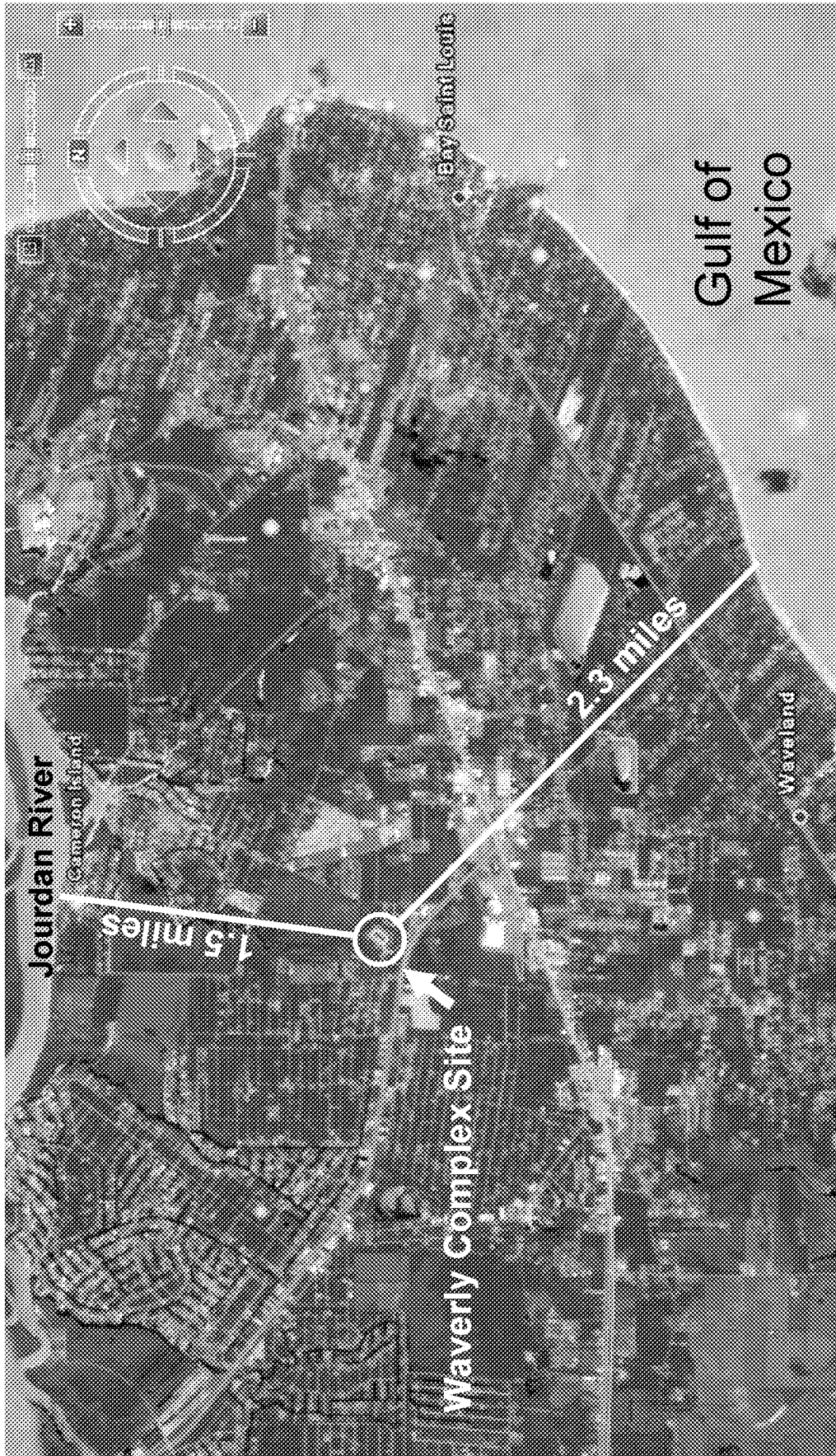


Figure 13. Google Earth aerial image of the Waverly Complex site (pre-Katrina)



Figure 14. Post-Katrina aerial image of the Waverly Complex site
(<http://ngs.woc.noaa.gov/storms/katrina/24439098.jpg>)